THE EFFECT OF SERIES CAPACITORS ON THE STEADY-STATE STABILITY OF TRANSMISSION LINES

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CHI MO CHENG

B.S., Ta Tung University, 1945
M.S., Purdue University, 1949

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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Although the installation of series capacitors has been usually limited to rural lines for the sole purpose of obtaining better voltage regulation, it has also been recognized as a potent means to increase the stability of transmission lines. In this thesis, the effect of series capacitors on the general performance of long transmission lines has been investigated, with the emphasis on the steady-state stability. The relationship between line constants A, B, C and D and transfer and driving impedances are clarified first. The constants of a line with series capacitors are then derived by means of matrix algebra. Voltages on both ends of the line are assumed to be constant in the stability study. This assumption is justified when sufficient reactive power is supplied by means of synchronous condensers installed on both ends, and is helpful to avoid unnecessary complications introduced by impedances of machines and terminal equipments which would distort the effect of series capacitors.

A typical line is used in the numerical calculations of the constants under conditions of (1) different line length, (2) different reactance of series capacitors, (3) different number of series capacitors, and (4) different resistance of the line. The result shows that series capacitors are effective and economical in increasing the stability and reducing the sizes of synchronous condensers normally required at both ends of the line for voltage control. The most favorable number of series capacitors is two in single-circuit lines.

Comparison has been made between the shunt and the series methods of capacitor connections on identical lossless lines. The shunt method has been found to be an ineffective and expensive means of increasing stability. Moreover, if the whole capacity of shunt capacitors is left on the line during

light load, the voltage on the line becomes very high.

The requirements of protective devices for series capacitors have been obtained by examining their response to surges due to switching, faults and lightning strokes. The frequency of the first two forms of surges are predominantly 60 cps. The capacitor voltage does not follow the surge voltage closely but still rises too rapidly and too highly. Fast-acting protective devices are therefore essential for protection against such surges. Shunting a resistance across the capacitor does not reduce the capacitor voltage under surges sufficiently. The capacitor voltage in response to a lightning surge is practically equal to the lightning surge voltage and consequently ordinary lightning arresters must be installed.

In series circuit with resistance, capacitance and saturated inductance, ferroresonance is known to occur under some conditions. It is extremely difficult to analyze mathematically a non-linear problem of this nature. In order to simplify the study of ferroresonance, the region above the knee of the transformer magnetization curve which is responsible for the occurence of ferroresonance is assumed to be linear in this thesis. The conclusions of this study indicate that series capacitors in power systems under normal operating conditions do not cause ferroresonance because their values are far from the right combination of circuit constants. Even if ferroresonance does occur in case of broken conductors, series capacitors are not responsible for the occurence. Since series capacitors give better voltage regulation, the exciting current at no load is actually reduced.

VITA

Chi Mo Cheng was born in Hong Kong, China, on January 29, 1924. He entered Ta Tung University, Shanghai, China, and received the degree of Bachelor of Science in Electrical Engineering from the same institution in 1945. He served as an assistant engineer in Taiwan Power Company, Taiwan, China on rehabilitation works. Upon resigning from the Company, he entered the Graduate School of Purdue University and received the degree of Master of Science in 1949. He is a member of the American Institute of Electrical Engineers and the Institute of Radio Engineers.